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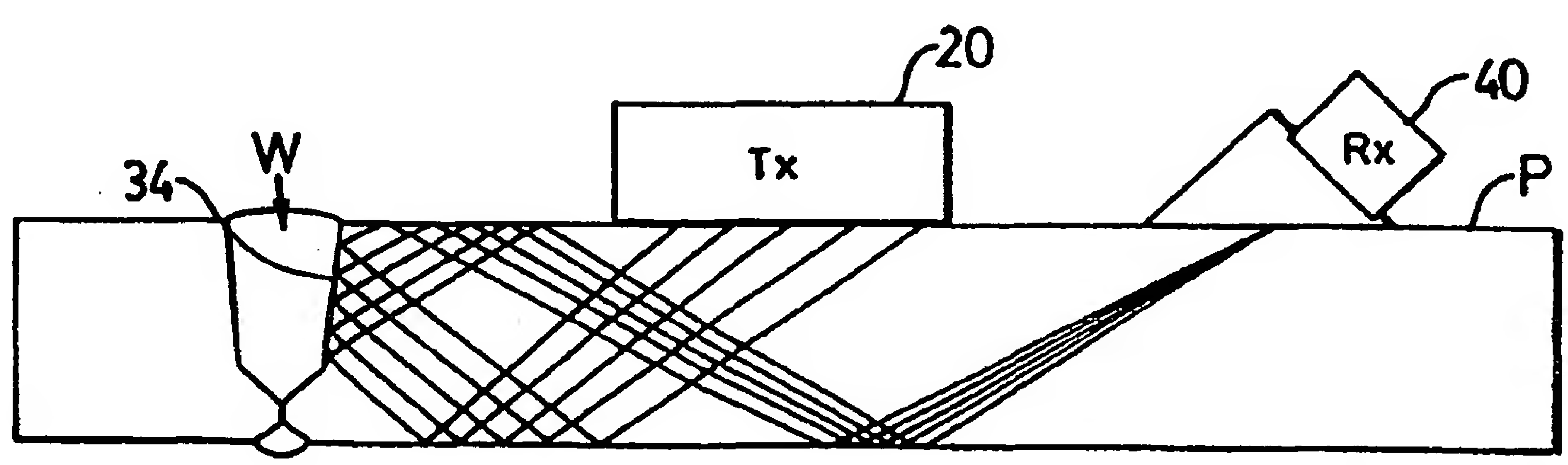
(54) Title: ULTRASONIC TESTING



(57) Abstract: A method of ultrasonic testing uses successive selections of independent elements of transducer to produce sonic energy to insonify successive zones along a path within a test piece, for example, along the height of a girth weld between two pipes, and an ultrasonic receiver to detect ultrasonic energy reflected or refracted at zones along the path. The beams of sonic energy from the successive selections of elements are focussed on zones and converge upon a common point at a receiver. Signals from the receiver represent the amplitudes of sonic energy reflected or refracted from successive zones.

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ULTRASONIC TESTING

FIELD OF THE INVENTION

This invention relates to automated ultrasonic testing (AUT), in which the reflection (or sometimes transmission) of ultrasonic radiation within a test piece is used to detect the presence of flaws.

REVIEW OF THE ART

Ultrasonic testing (UT) techniques typically rely upon focusing ultrasonic energy at successive locations within a structure to be tested, and collecting energy reflected from such points using a receiver also focused on the successive locations.

One focusing technique widely used in such applications is the phased array, in which an array of ultrasonic transducers is operated in such a manner that the phasing of transmit pulses applied to the transducers determines both the distance and direction of a focus at which transmitted pulses from the array will arrive at the same time. A similar technique is used to receive reflected or refracted pulses, with the output of elements in a receiver array being gated at phased intervals selected so as to receive energy from the focus of the receiver. A disadvantage of such systems is that the complexity and cost, particularly of the receiver, are quite high.

SUMMARY OF THE INVENTION

We have found that, in certain suitable applications, as good or even better performance than a typical phased array system as mentioned above, or other system using a focused transmitter and a focused receiver, can be obtained without the need for a sophisticated focused receiver.

More specifically, when inspecting a zone of finite

width and known orientation across that width, focussed beam from successive groups of element in a phased array transmitter can be directed at successively varying angles so that the feature of the workpiece to be examined reflects or refracts the beams, which are angled to converge at the receiver.

More specifically, the invention provides a method of ultrasonic testing using successive selections of independent elements of a transducer array phased to produce sonic energy focussed on successive zones along a path within a test piece, and an ultrasonic receiver to detect ultrasonic energy reflected or refracted at zones along said path, wherein the sonic energy from the successive selections of elements are phased so as have a progressively varying angle of incidence on the path such as to converge on a transducer in the receiver, and signals from the receiver represent the amplitudes of sonic energy reflected or refracted from successive zones along the path. Preferably the path lies along the height of a girth weld in a pipe or vessel, and the method includes rotating the transmitter and receiver relative to the pipe or vessel to bring successive portions of the weld in line with said path.

Further features of the invention will become apparent from the following description with reference to the accompanying drawings.

SHORT DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram illustrating the principle of an ultrasonic phased array transmitter;

Figure 2 schematically illustrates an UT system utilizing a phased array transmitter and receiver;

Figure 3 is a diagram illustrating transmission paths in the system of Figure 2 as applied to the inspection of a

girth weld;

Figure 4 is a diagram illustrating transmission path in a system according to the present invention; and

Figure 5 schematically illustrates an UT system in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Figure 1 shows a prior art phased array acoustic transmitter. A transmitter array of acoustic sources or elements 2 is provided, these elements being independent from each other both electrically and acoustically and small enough to be considered point or line sources. Because of their independence they can be fired or exited by electrical pulses that are out of phase with each other. The out of phase sequence and firing of these elements allows for the focussing, steering and shifting of a focal point 6, at which the wave fronts 8 from the elements intersect. The size of a group 4 of active elements centered on an index relative to an end of the array determines the Aperture A of the group (Figure 1 clarifies the definition of these parameters). Hence by selecting the set of elements selected for firing and their respective phase delays, the characteristics of the array can be electronically controlled. It quickly can be seen that one Phased Array (PA) transducer can replace several conventional probes and hence reduce physical complexity of UT equipment (which is replaced by electronic complexity). Though the phased array concept is easiest to envision in a transmitting environment, it equally works as a receiver. It should be noted however that the increase in complexity in the electronic circuitry is mostly associated with the receiver side. Figure 2 shows a block diagram of a typical prior art system. Synchronizing signals 10 are subjected in a delay element 12 to delays determined by a control signal 14 and

drive a pulse generator 16 before being directed by a selector circuit 18 to appropriate elements in a transmitter array 20. Similarly signals received by elements in a receiver array 22 are selected by a circuit 24, are amplified in an amplifier 25, converted to digital signals in an A/D converter 26 and delayed, summed and gated by a circuit 28 under control of a signal 29 to provide an output signal 30 indicative of the strength of the signal reflected from the focus.

In certain applications, for example, the ultrasonic testing of girth welds in pipes or vessels, there is interest only in the detection of flaws in a zone of defined geometry, finite height and small width. We have found that such constraints enable the conventional phased array ultrasonic testing equipment to be simplified substantially with no loss and possibly an improvement in performance.

Referring first to Figure 3, which illustrates the application of phased array transducers to the wall P of a pipe including a girth weld W to be inspected, it will be seen that energy from successive groupings of elements of the transmitter array 20 is focussed in parallel beams onto successive locations across the height of a weld interface 34 to be examined. Energy reflected from the weld is picked up by successive groupings of elements of a phased array receiver 22, and processed to provide an output signal. Flaws in the weld will produce variations in the receiver output as the apparatus and the pipe are moved relatively so as to scan the peripheral extent of the weld.

In the arrangement according to the invention shown in Figure 4, the beams from an array of elements in the transmitter 20 are directed so as to converge onto a simplified receiver 40, the beam following a converging path and the aperture of the transmitter being selected so that the weld to be examined is a reflector in that path at a point at which the aperture of the converging beams is

comparable to the height of the weld interface 34. As in the conventional system, beams from successively selected sets of elements may be generated such that sequentially received signals represent successive portions of the height of the weld so that the width-wise position of a flaw in the weld can be determined.

A block diagram of a system according to the invention is shown in Figure 5. In Figure 5, the transmitter is very similar to that of Figure 2 and will not be described further, except that the array of elements is broader so that the directions of beams from successive groups of elements within the transmitter can converge on the receiver, but still have a sufficient aperture at the weld to encompass the height of the latter. The receiver 40 however is considerably simplified, and consists of a receiver element, or group of elements, located at the convergence of the transmitted beams, and connected to a preamplifier 42 and analog to digital converter 44 to provide an output 46. A control signal 48 merely controls the converter 44 and the receiver is therefore much simpler than that of Figure 2,

It will be understood that the above-described embodiment is exemplary only, and developments and modifications are possible within the scope of the appended claims.

CLAIMS:

1. A method of ultrasonic testing using successive selections of independent elements of a transducer array phased to produce sonic energy focussed on successive zones along a path within a test piece, and an ultrasonic receiver to detect ultrasonic energy reflected or refracted at zones along said path, wherein the sonic energy from the successive selections of elements are phased so as have a progressively varying angle of incidence on the path such as to converge on a transducer in the receiver, and signals from the receiver represent the amplitudes of sonic energy reflected or refracted from successive zones along the path.

2. A method according to claim 1, wherein the path is the height of a girth weld in a pipe or vessel, and the method includes rotating the transmitter and receiver relative to the axis of the pipe or vessel, to bring successive portions of the weld in line with said path.

3. Apparatus for ultrasonic testing comprising a phased array ultrasonic transmitter formed by multiple independent ultrasonic transducer elements, means to select successive groups of said elements and energize them in phased sequence so as to focus beams of ultrasonic energy from each of said groups at zones along a path within a test piece, the directions of the beams being such as to converge at a common point beyond said zone, and a receiver located at said common point to determine the magnitude of ultrasonic energy reflected or refracted at successive points along said zone.

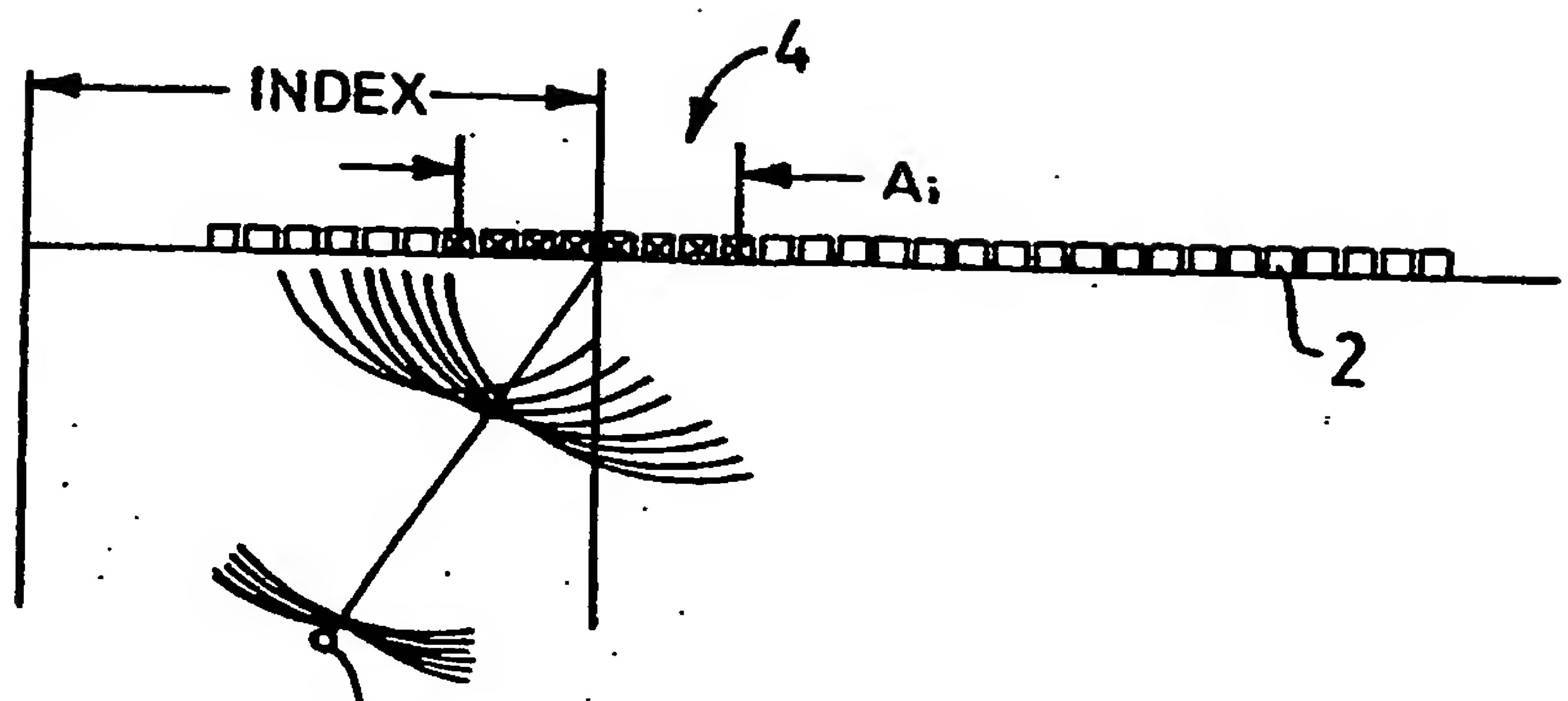
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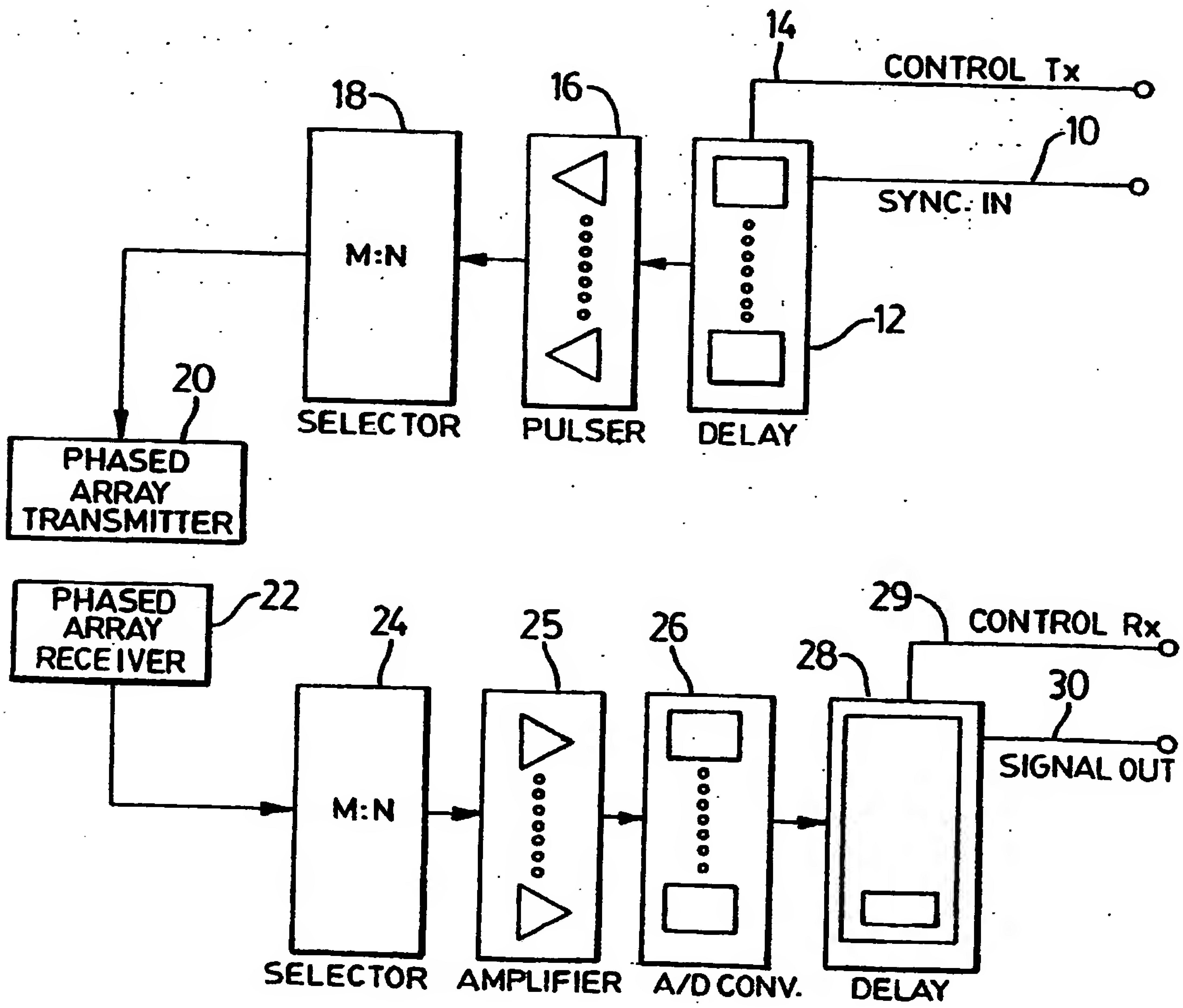
FIG. 1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CONTROL Rx
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SIGNAL OUT
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SELECTOR
AMPLIFIER
A/D CONV.
DELAY

FIG. 2

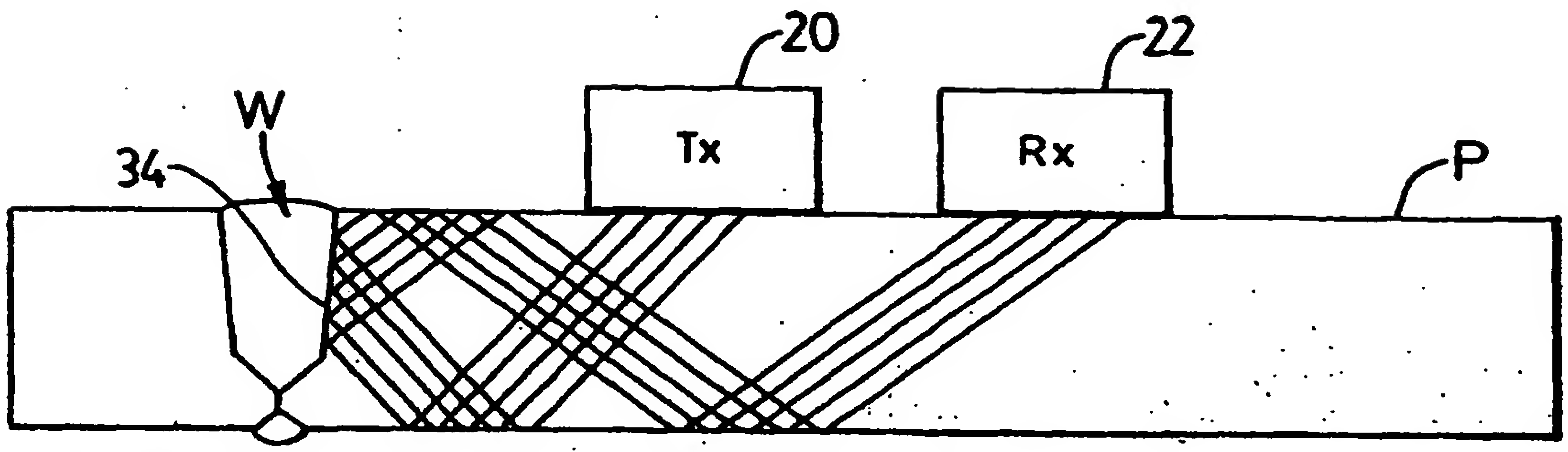

FIG. 3

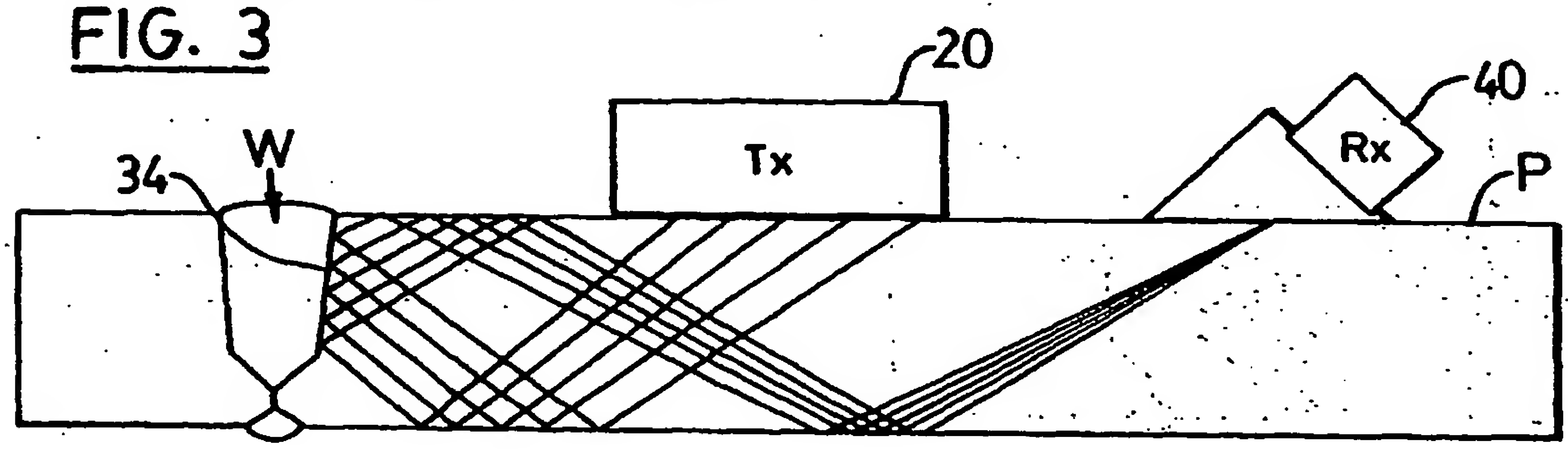

FIG. 4

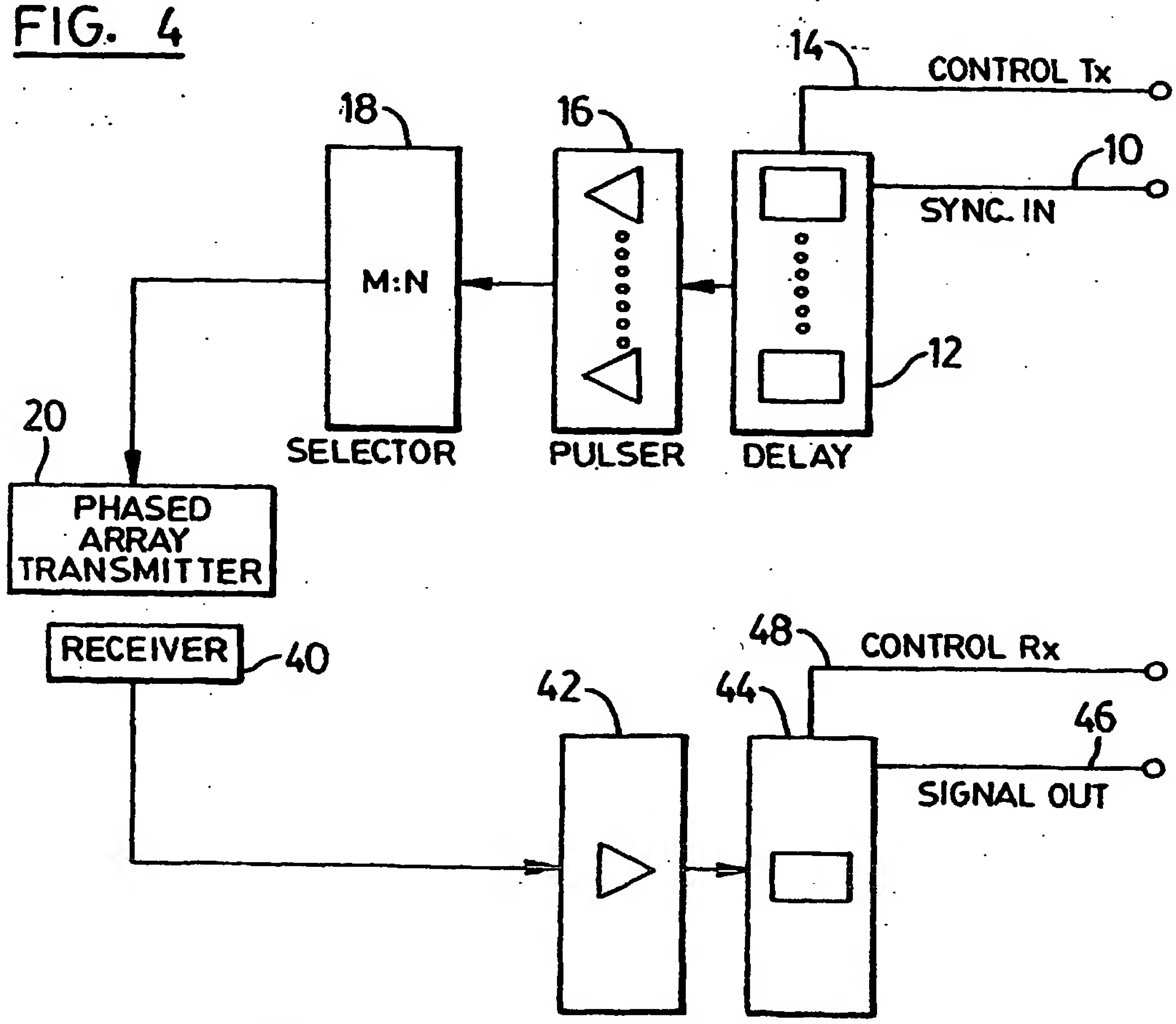

FIG. 5

INTERNATIONAL SEARCH REPORT

International Application No
PCT/CA 01/00241

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01N29/10

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 821 575 A (FUJIKAKE YOICHI ET AL) 18 April 1989 (1989-04-18) abstract column 3, line 17 -column 4, line 25; figure 1	1-3
A	DE 37 15 914 A (FRAUNHOFER GES FORSCHUNG) 1 December 1988 (1988-12-01) abstract column 4, line 7 -column 5, line 6; figure 3	1-3
A	US 4 523 468 A (DERKACS THOMAS ET AL) 18 June 1985 (1985-06-18) abstract column 2, line 67 -column 3, line 40; figure 1	1-3

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
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Name and mailing address of the ISA	Authorized officer
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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